

TRANSMIT REQUEST SIGNALING BETWEEN TRANSCEIVERS

Cross-Reference to Related Applications

[0001] This application claims the benefit of:

1. U.S. provisional application Serial Number 60/452,309, filed 5 March 2003, entitled "Blue802 Polite Request" (Attorney Docket:680-040us), which is also incorporated by reference.

[0002] The following patent applications are incorporated by reference:

1. U.S. patent application Serial Number 10/444,383, entitled "Multi-Protocol Interchip Interface" (Attorney Docket: 680-021us),
2. U.S. patent application Serial Number 10/444,519, entitled "Coordination of Competing Protocols" (Attorney Docket: 680-030us), and
3. U.S. patent application Serial Number 10/____,____, entitled "Coordinating Multiple Air-Interface Subsystems that Serve a Common Host," (Attorney Docket: 680-059us).

Field of the Invention

[0003] The present invention relates to telecommunications in general, and, more particularly, to wireless local area networks.

Background of the Invention

[0004] FIG. 1 depicts a schematic diagram of local area network 100 in the prior art, which comprises telecommunication stations 101-1 through 101-K, wherein *K* is a positive integer, and shared-communications channel 102, interconnected as shown. Stations 101-1 through 101-K enable associated host computers to communicate blocks of data, or "frames," to each other. Stations 101-1 through 101-K comprise transceivers that enable communications via shared-communications channel 102.

[0005] In a mixed network such as local area network 100, some of the stations (e.g., station 101-1, etc.) operate in accordance with the IEEE 802.11 set of protocols, and some of the stations (e.g., station 101-4, etc.) operate in accordance with the Bluetooth set of protocols. Still other stations of local area network 100 operate in accordance with both protocols. The stations comprising transceivers that communicate in accordance with IEEE

802.11 are able to take turns accessing shared-communications channel 102 because they all embody IEEE 802.11 access rules and follow those rules. Similarly, the stations comprising transceivers that communicate in accordance with Bluetooth are able to take turns accessing shared-communications channel 102 because they all embody Bluetooth access rules and follow those rules.

[0006] When IEEE 802.11 transceivers and Bluetooth transceivers—situated either in separate stations or within the same station—have to use the same, shared-communications channel (*i.e.*, shared-communications channel 102), the rules for accessing (and sharing) shared-communications channel 102 are not as well defined as for the case where all transceivers use the same protocol. For example, Bluetooth station 101-4 might attempt to transmit when IEEE 802.11 station 101-1 is already transmitting, and the result would most likely be that neither station successfully transmits during that particular attempt. Depending on the contention for shared-communications channel 102, neither the Bluetooth stations nor the IEEE 802.11 stations would operate effectively enough to be of much value to the end user.

[0007] Therefore, the need exists for a way to coordinate multiple air interface protocols that are used to access the same, shared-communications channel without some of the disadvantages in the prior art.

Summary of the Invention

[0008] The present invention enables both an IEEE 802.11 transceiver and a Bluetooth transceiver to be employed in a single telecommunication station without the transceivers interfering on each other. In particular, the illustrative embodiment enables standard, “off-the-shelf,” IEEE 802.11 and Bluetooth transceivers to work in a coordinated fashion in a single telecommunications station. In some embodiments, the two transceivers are in separate stations.

[0009] In the illustrative embodiment, a Bluetooth transceiver notifies an IEEE 802.11 transceiver that is using a shared-communications channel that the Bluetooth transceiver needs to use the shared-communications channel, though not necessarily immediately. The channel access control mechanism associated with the IEEE 802.11 transceiver determines when to relinquish control of the shared-communications channel to the Bluetooth transceiver and then grants the Bluetooth transceiver’s request to use the

shared-communications channel. The IEEE 802.11 transceiver can choose to (i) power down or (ii) stay powered up when it relinquishes control of the shared-communications channel.

[0010] In some embodiments, the Bluetooth transceiver notifies the IEEE 802.11 transceiver when the Bluetooth transceiver finishes using the shared-communications channel. In other embodiments, the Bluetooth transceiver notifies the IEEE 802.11 transceiver *in advance* when the Bluetooth transceiver begins to finish using the shared-communications channel. The Bluetooth transceiver in those other embodiments then continues to use the shared-communications channel during the recovery period when the IEEE 802.11 transceiver transitions from a powered down to a powered up condition.

[0011] In this specification, the illustrative embodiment is disclosed in the context of the IEEE 802.11 and Bluetooth protocols. It will be clear to those skilled in the art, however, how to make and use alternative embodiments of the present invention for other combinations of competing protocols (*i.e.*, protocols that might interfere with each other). In addition, although the illustrative embodiment is disclosed in the context of radio transceivers, it will be clear to those skilled in the art how to make and use alternative embodiments of the present invention for non-radio frequency wireless devices or wireline transceivers that might interfere with each other.

[0012] The illustrative embodiment of the present invention comprises: asserting a polite request signal that requests that a first transceiver relinquish transmitting via a shared-communications channel, wherein the first transceiver communicates in accordance with a first communications protocol; indicating via the shared-communications channel that a second transceiver hold subsequent transmissions to the first transceiver; asserting a first signal from the first transceiver that indicates that the first transceiver has relinquished transmitting via the shared-communications channel; and transmitting at least one frame from a third transceiver via the shared-communications channel after the asserting of the first signal, wherein the third transceiver communicates in accordance with a second communications protocol.

Brief Description of the Drawings

[0013] FIG. 1 depicts a schematic diagram of wireless local area network 100 in the prior art.

[0014] FIG. 2 depicts a schematic diagram of a portion of local area network 200 in accordance with the illustrative embodiment of the present invention.

[0015] FIG. 3 depicts a block diagram of the salient components of dual station 204-1 in accordance with the illustrative embodiment of the present invention.

[0016] FIG. 4 depicts a block diagram of the salient components of air interface subsystem 301-*i* in accordance with the illustrative embodiment of the present invention.

[0017] FIG. 5 depicts a timing diagram of signals exchanged between air interface subsystems 301-1 and 301-2, in accordance with the first illustrative embodiment of the present invention.

[0018] FIG. 6 depicts a timing diagram of signals exchanged between air interface subsystems 301-1 and 301-2, in accordance with the second illustrative embodiment of the present invention.

Detailed Description

[0019] FIG. 2 depicts a schematic diagram of a portion of local area network 200 in accordance with the illustrative embodiment of the present invention. Network 200 operates in accordance with the IEEE 802.11 and Bluetooth sets of protocols, and comprises access point 201, first protocol 802.11 stations 202-1 through 202-*L*, wherein *L* is a natural number; second protocol stations 203-1 through 203-*M*, wherein *M* is a natural number; dual protocol stations 204-1 through 204-*N*, wherein *N* is a natural number; host computers 205-1 through 205-*P*, wherein *P* is equal to the sum of *L*, *M*, and *N*; and wireless shared-communications channel 206, interconnected as shown.

[0020] FIG. 2 depicts a network configuration with *L* equal to two, *M* equal to two, and *N* equal to one. It will be clear, however, to those skilled in the art, after reading this specification, how to make and use embodiments of the present invention that use different values for *L*, *M*, and *N*.

[0021] In the examples provided in this specification, first protocol stations 202-1 through 202-*L* and second protocol stations 203-1 through 203-*M* are IEEE 802.11 and Bluetooth compliant, respectively. Furthermore, dual stations 204-1 through 204-*N* are both IEEE 802.11 and Bluetooth compliant. Access point 201, a coordinating station that is described below, is at least IEEE 802.11 compliant. In some embodiments, access point 201 is both IEEE 802.11 and Bluetooth compliant. It will be clear, however, to those skilled in the art, after reading this specification, how to make and use embodiments of the present invention that operate in accordance with other protocols. Furthermore, it will be clear to those skilled in the art, after reading this specification, how to make and use

embodiments of the present invention that use a wireline or tangible shared-communications channel.

[0022] Access point 201 coordinates the communications of at least some of the stations within local area network 200. For example, first protocol stations 202-1 through 202-*L* and dual protocol stations 204-1 through 204-*N*, when using the protocol of first protocol stations 202-1 through 202-*L*, communicate with each other through access point 201. It will be clear to those skilled in the art how to make and use access point 201.

[0023] Each station comprises one or more transceivers that enable host computer 205-*j*, for *j*=1 to *P*, to transmit signals and receive signals via shared-communications channel 206. A "transceiver" is capable of two-way communication over a communications channel (e.g., shared-communications channel 206, etc.). For example, dual station 204-1 is capable of receiving data blocks from host computer 205-5 (*i.e.*, the host computer with which dual station 204-1 is associated) and transmitting over shared-communications channel 206 data frames comprising the data received from host computer 205-5. Dual station 204-1 is also capable of receiving data frames from shared-communications channel 206 and sending to host computer 205-5 data blocks comprising data from the data frames. It will be clear to those skilled in the art, after reading this specification, how to make and use dual station 204-1. The salient details for dual station 204-1 are described below and with respect to FIG. 3.

[0024] Host computer 205-*j*, for *j*=1 to *P*, is capable of generating data blocks and transmitting those data blocks to its associated station. Host computer 205-*j* is also capable of receiving data blocks from its associated station and of processing and using the data contained within those data blocks. Host computer 205-*j* can be, for example, a desktop computer, a laptop computer, a wireless telephone, or a personal digital assistant (PDA) that uses local area network 200 to communicate with other hosts and devices. It will be clear to those skilled in the art how to make and use host computer 205-*j*.

[0025] FIG. 3 depicts a block diagram of the salient components of dual station 204-1 in accordance with the illustrative embodiment of the present invention. Dual station 204-1 supports two distinct wireless air interface protocols for the purpose of transmitting and receiving data over the air via shared-communications channel 206. The wireless protocols supported by dual station 204-1 can be, for example, IEEE 802.11 and Bluetooth. Dual station 204-1 comprises: air interface subsystem 301-1, air interface subsystem

301-2, and antenna switch 302, interconnected as shown: Air interface subsystem 301-1 and air interface subsystem 301-2 communicate with each other via interface 303.

[0026] Air interface subsystem 301- i , for $i=1$ to Q wherein Q is a positive integer greater than one, enables associated host computer 205- j (*i.e.*, host computer 205-5 paired with dual station 204-1) to communicate via shared-communications channel 206. In the illustrative example, Q is equal to two. It will be clear, however, to those skilled in the art, after reading this specification, how to make and use dual station 204- i with other values of Q .

[0027] Air interface subsystems 301-1 and 301-2 comprise the transceivers that enable host computer 205- j to communicate using two different air interface protocols. Each of air interface subsystems 301-1 and 301-2 operates in accordance with a different air interface protocol (*e.g.*, IEEE 802.11, Bluetooth, *etc.*). It will be clear to those skilled in the art, after reading this specification, how to make and use air interface subsystems 302-1 and 302-2.

[0028] Antenna switch 302 enables air interface subsystems 301-1 and 301-2 to share a single antenna unit for the purpose of using shared-communications channel 206. Antenna switch 302 provides signals to air interface subsystem 301- i . Antenna switch 302 also accepts signals from air interface subsystem 301- i . It will be clear to those skilled in the art how to make and use antenna switch 302.

[0029] FIG. 4 depicts a block diagram of the salient components of air interface subsystem 301- i in accordance with the illustrative embodiment of the present invention. Air interface subsystem 301- i comprises receiver 401- i , processor 402- i , memory 403- i , and transmitter 404- i , interconnected as shown.

[0030] Receiver 401- i is a circuit that is capable of receiving frames from shared-communications channel 206, in well-known fashion, and of forwarding them to processor 402- i . It will be clear to those skilled in the art, after reading this specification, how to make and use receiver 401- i .

[0031] Processor 402- i is a general-purpose processor that is capable of performing the tasks described below and with respect to FIGs. 5 through 9. Processor 402- i controls access to shared-communications channel 206 for air interface subsystem 301- i in accordance with the applicable air interface protocol. It will be clear to those skilled in the art, after reading this specification, how to make and use processor 402- i .

[0032] Memory 403-*i* is capable of storing programs and data used by processor 402-*i*. It will be clear to those skilled in the art how to make and use memory 403-*i*.

[0033] Transmitter 404-*i* is a circuit that is capable of receiving frames from processor 402-*i*, in well-known fashion, and of transmitting them on shared-communications channel 206. It will be clear to those skilled in the art, after reading this specification, how to make and use transmitter 404-*i*.

[0034] The combination of receiver 401-*i* and transmitter 404-*i* constitutes the transceiver part of air interface subsystem 301-*i*.

[0035] FIG. 5 depicts a timing diagram of signals exchanged between air interface subsystem 301-1 and 301-2, in accordance with the first illustrative embodiment of the present invention. In accordance with the first illustrative embodiment of the present invention, FIG. 5 depicts air interface subsystem 301-2 requesting that air interface subsystem 301-1 relinquish control of shared-communications channel 206, though not necessarily immediately. In this specification, this action is referred to as a "polite request." The polite request signal, when not asserted, also indicates when air interface subsystem 301-2 is not transmitting into shared-communications channel 206. Although air interface subsystems 301-1 and 301-2 of dual station 204-1 are used as examples, it will be clear to those skilled in the art how to apply the tasks represented in FIG. 5 of the illustrative embodiment to other air interface subsystems.

[0036] In some embodiments, signals are conveyed as discrete signal levels, and in other embodiments, signals are conveyed as packets. FIG. 5 depicts signals occurring in both forms. It will be clear to those skilled in the art, after reading this specification, how to represent in actual implementation the signals depicted in FIG. 5.

[0037] At time 501, air interface subsystem 301-2 asserts a polite request signal, which is subsequently detected by air interface subsystem 301-1. Asserting the polite request signal indicates that air interface subsystem 301-2 needs to use shared-communications channel 206, though not necessarily immediately.

[0038] Air interface subsystem 301-1 detects the polite request signal being asserted by air interface subsystem 301-2. Air interface subsystem 301-1 can relinquish control of shared-communications channel 206 immediately, or it can defer relinquishing control. It will be clear to those skilled in the art how to determine when air interface subsystem 301-1 relinquishes control of shared-communications channel 206.

[0039] At time 502 when it is ready to relinquish control of shared-communications channel 206, air interface subsystem 301-1 indicates to access point 201 to hold data frames arriving from other sources and that are addressed to air interface subsystem 301-1. For example, the indication can be in the form of a message bit set to a value indicating that the transceiver of air interface subsystem 301-1 is entering a power save state in which air interface subsystem 301-1 powers down the transceiver. Air interface subsystem 301-1 can direct the action of powering down at the transmitter part, the receiver part, or both parts of the transceiver. In some embodiments, air interface subsystem 301-1 keeps its transceiver powered up, even though it informed access point 201 otherwise.

[0040] At time 503, air interface subsystem 301-1 receives an acknowledgement that access point 201 received the indication.

[0041] At time 504, air interface subsystem 301-1 sends a request granted signal to air interface subsystem 301-2 to indicate that air interface subsystem 301-1 yields shared-communications channel 206 and that air interface subsystem 301-2 can use shared-communications channel 206.

[0042] At time 505, air interface subsystem 301-2 begins using shared-communications channel 206 for transmitting, receiving, or both.

[0043] At time 506, air interface subsystem 301-2 determines that it is near the end of operation on shared-communications channel 206 and un-asserts the polite request signal. In some embodiments, air interface subsystem 301-1 as a result begins a recovery interval, which is a transition period that the transceiver goes through while powering up.

[0044] At time 507, air interface subsystem 301-1 informs access point 201 that air interface subsystem 301-1 has exited the power save state. For example, the PS-Poll frame is used in IEEE 802.11 for this purpose.

[0045] At time 508, air interface subsystem 301-1 receives an acknowledgement from access point 201. Air interface subsystem 301-1 proceeds to receive the data frames that have been held by access point 201 since time 502.

[0046] FIG. 6 depicts a timing diagram of signals exchanged between air interface subsystem 301-1 and 301-2, in accordance with the second illustrative embodiment of the present invention. In accordance with the second illustrative embodiment of the present invention, FIG. 6 depicts air interface subsystem 301-2 requesting that air interface subsystem 301-1 relinquish control of shared-communications channel 206, though not necessarily immediately. When it relinquishes control, air interface subsystem 301-1 enters

and exits a power save state as described below. In the second illustrative embodiment of the present invention, air interface subsystem 301-2 uses separate polite request and transmit indications, which enable air interface subsystem 301-2 to continue transmitting while air interface subsystem 301-1 is exiting and recovering from the power save state. Although air interface subsystems 301-1 and 301-2 of dual station 204-1 are used as examples, it will be clear to those skilled in the art how to apply the tasks represented in FIG. 6 of the illustrative embodiment to other air interface subsystems.

[0047] In some embodiments, signals are conveyed as discrete signal levels, and in other embodiments, signals are conveyed as packets. FIG. 6 depicts signals occurring in both forms. It will be clear to those skilled in the art, after reading this specification, how to represent in actual implementation the signals depicted in FIG. 6.

[0048] At time 601, air interface subsystem 301-2 asserts a polite request signal, which is subsequently detected by air interface subsystem 301-1. Asserting the polite request signal indicates that air interface subsystem 301-2 needs to use shared-communications channel 206, though not necessarily immediately.

[0049] Air interface subsystem 301-1 detects the polite request signal being asserted by air interface subsystem 301-2. Air interface subsystem 301-1 can relinquish control of shared-communications channel 206 immediately, or it can defer relinquishing control. It will be clear to those skilled in the art how to determine when air interface subsystem 301-1 relinquishes control of shared-communications channel 206.

[0050] At time 602 when it is ready to relinquish control of shared-communications channel 206, air interface subsystem 301-1 indicates to access point 201 to hold data frames arriving from other sources and that are addressed to air interface subsystem 301-1. For example, the indication can be in the form of a message bit set to a value indicating that the transceiver of air interface subsystem 301-1 is entering the power save state in which air interface subsystem 301-1 powers down the transceiver.

[0051] At time 603, air interface subsystem 301-1 receives an acknowledgement that access point 201 received the indication.

[0052] At time 604, air interface subsystem 301-1 enters the power save state. Air interface subsystem 301-1 can direct the action of powering down at the transmitter part, the receiver part, or both parts of the transceiver. In some embodiments, air interface subsystem 301-1 keeps its transceiver powered up, even though it informed access point 201 otherwise.

[0053] At time 605, air interface subsystem 301-1 sends a request granted signal to air interface subsystem 301-2 to indicate that air interface subsystem 301-1 yields shared-communications channel 206 and that air interface subsystem 301-2 can use shared-communications channel 206.

[0054] At time 606, air interface subsystem 301-2 asserts the transmit indication signal.

[0055] At time 607, air interface subsystem 301-2 begins using shared-communications channel 206 for transmitting, receiving, or both.

[0056] At time 608, air interface subsystem 301-2 determines that it is near the end of operation on shared-communications channel 206 and un-asserts the polite request signal. In some embodiments, air interface subsystem 301-1 begins a recovery interval, which is a transition period that the transceiver goes through while powering up. Air interface subsystem 301-2 continues transmitting into shared-communications channel 206.

[0057] At time 609, air interface subsystem 301-2 ceases using shared-communications channel 206 and un-asserts the transmit indication signal.

[0058] At time 610, air interface subsystem 301-1 completes the powering-up recovery and exits the power save state in those embodiments in which it had entered the power save state. Air interface subsystem 301-1 detects the un-asserting of the transmit indication signal of air interface subsystem 301-2 and resumes using shared-communications channel 206 as needed.

[0059] At time 611, air interface subsystem 301-1 informs access point 201 that air interface subsystem 301-1 has exited the power save state. For example, the PS-Poll frame is used in IEEE 802.11 for this purpose.

[0060] At time 612, air interface subsystem 301-1 receives an acknowledgement from access point 201. Air interface subsystem 301-1 proceeds to receive the data frames that have been held by access point 201 since time 602.

[0061] It is to be understood that the above-described embodiments are merely illustrative of the present invention and that many variations of the above-described embodiments can be devised by those skilled in the art without departing from the scope of the invention. It is therefore intended that such variations be included within the scope of the following claims and their equivalents.

[0062] What is claimed is: